The Science of IAQ in Schools

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Student Performance & IAQ

- Review causes of poor indoor air quality (IAQ)
- General considerations for measuring student performance & IAQ
- Selected studies and results
- Summary

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- Large amount of information on health effects of poor IAQ
- Relatively few studies of student performance and IAQ
- Very difficult area to study
- Must examine studies of office workers as well

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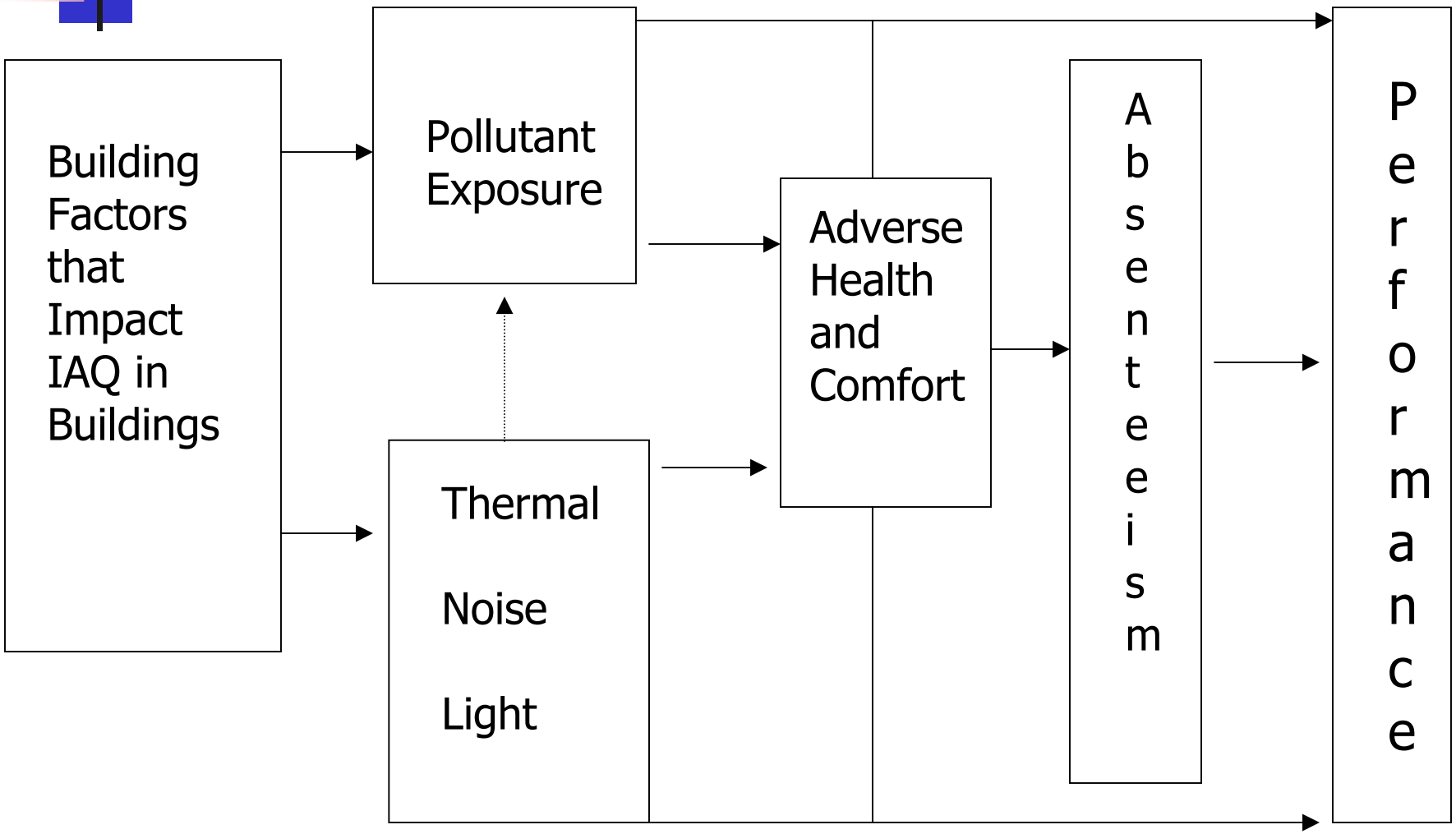
- Why is it so difficult to study?
  - Many variables can affect student performance
    - IAQ is only one of the variables (and IAQ is multifactorial also)
  - Variables are difficult to control
    - There are many confounders

How Does IAQ Affect Performance?



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- Building Factor Failures Result in Poor IAQ
  - Failure to control pollutant sources
    - For example, art supplies and lab activities
  - Failure to control temperature and humidity
  - Failure to control moisture and spills
  - Failure to ventilate adequately
  - Failure to perform housekeeping and maintenance adequately or properly including IPM

Could be either design, construction, or O&M failures or some combination….multifactorial

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- Examples of variables that can affect student performance
  - Curriculum
  - Home situation
  - Infectious disease
  - New students or teacher
- IAQ is multifactorial (also has many variables)
  - Environmental parameters (chemicals, biological contaminants, particulate matter)
  - Thermal factors (temperature, relative humidity, air velocity)
  - Ventilation

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How can we measure student performance?

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- How can we measure student performance?
- Three of several possibilities
  - Standardized tests
  - Human factors (quasi-direct/quantitative)
  - Absenteeism (indirect but important)

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- Standardized Tests
  - Direct and important measure
  - Becoming more common
  - May not be sufficiently sensitive for small changes. Year to year variations normal
  - Still subject to confounders. Need controls. Could compare “changes” in scores.

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- Human Factors (core skills)
  - Measures of concentration, recall, reading comprehension, arithmetic skills, etc.)
  - Standardized measures available
  - Sensitive to small changes
  - May be less subject to confounders ??Still need controls

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- Absenteeism
  - Effect is easily measured
  - But relatively crude measure
    - Doesn’t measure decrements in performance while at school
  - An epidemic or high pollen counts outdoors can compromise study
  - But isn’t it an important variable?

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- Types of Studies
  - Chamber vs. Field Studies
  - Longitudinal (follow in time) vs. Cross-sectional (extensive snapshot in time)
  - Intervention Studies
    - **Pre-intervention measurement; intervention; post-intervention measurement**
  - Beware--All studies need controls

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- Recently Updated Fact Sheet—IAQ and Student Performance-- provides summary of evidence.
  - www.epa.gov/iaq. Go to publications.
  - Update based on extensive literature review by LBL. Tried to get educational research journals to publish…..no dice
  - Also see www.IHPcentral.org for a searchable bibliography on IAQ, health, and productivity.

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- Many studies relate IAQ to respiratory health.
  - Moisture/water damage, animal & biological allergens, combustion pollutants
- Respiratory health, especially especially infections and asthma, are a leading cause of school absences

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- **Low Ventilation or High Pollution**
  - Several studies show that low ventilation rates, or higher levels of indoor pollution adversely effect health symptoms, perceived quality of IAQ, and various measures of productivity or absences.
  - Some data is from office environments

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- Housekeeping, Maintenance
  - Studies show fewer health symptoms with lower levels of dust and more frequent cleaning. Studies are building
  - Reasonable evidence that improved maintenance is important to good IAQ. Only one good study.

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- Example of Individual Studies
  - Swedish School Study
  - Danish Office Study

  - *Note: The Europeans, especially the Scandinavians, are pursuing this field much more intensively than the U.S.*

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- Swedish Study of 800 students in 8 schools(1996)
  - Related CO_2 to student performance and symptoms (also measured VOC, RH, T but not reported); ages 15 to 20
  - Both health indices (headache, tiredness, difficulty concentrating; and eye and upper airway irritation) correlated positively to CO_2 concentration (lower ventilation, more crowding)
  - Performance (tests of concentration) decreased with higher CO_2 concentrations (lower ventilation, more crowding)

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- Why Measure Carbon Dioxide???

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- Why measure CO_2?
  - CO_2 does not generally cause health effects at levels observed in typical indoor environments (OSHA Standard is 10,000 ppm)
  - Lack of oxygen is not a limiting factor, …. but
  - Everyone expires CO_2, ……therefore
  - CO_2 is often as a measure of ventilation relative to the number of people present in a given space
  - ASHRAE Standard of 15 cfm/occupant ~1,000 ppm
    - (Cautions are in order here)

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- Danish Controlled Field Study (2000)
  - Three offices in two countries
  - IAQ Controls: Large changes in ventilation or the introduction of a hidden 20-yr old carpet
  - Perception of IAQ and performance on text typing, proof-reading & addition all improved with better IAQ (2%-6% range)
  - Creative thinking improved with ventilation

Student Performance and IAQ

- Danish Studies on Thermal Effects on Performance (1974-2002)
  - Simulated controlled office environment
  - Cooler temperatures and lower RH within comfort zone associated with lower SBS, improved IAQ perception and improved performance (mixed)
  - Conditions for highest performance not same as greatest comfort

Student Performance & IAQ

- **Summary**
  - Studies suggest poor IAQ degrades student performance (also very plausible)
    - Evidence is building—slowly but steadily
  - Good Studies are difficult and expensive
  - Need to examine studies in other environments (e.g. offices)
  - Need to interest educational research community—any ideas??